

EMERGENCY DEPARTMENT

Corticosteroid Timing and Length of Stay for Children with Asthma in the Emergency Department

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Objective. The aim of this study was to evaluate the relationship between time of corticosteroid administration to children with asthma exacerbations in the Emergency Department (ED) and length of stay (LOS). We hypothesized administration within 60 minutes would be associated with a 10-minute or greater decrease in mean LOS. **Methods.** A retrospective chart review of 882 patients was conducted. Children between the ages of 2 and 18 years presented to the Connecticut Children's Medical Center's (CCMC's) ED with an acute asthma exacerbation were included. Children were excluded if they did not receive oral corticosteroids in the ED, had significant co-morbidities, were currently taking corticosteroids, or had taken them within the past 7 days. Children receiving corticosteroids within 60 minutes of triage were compared with children receiving corticosteroids for 61 minutes or later. The primary outcome was mean LOS. **Results.** Children treated with corticosteroids within 60 and 61 minutes or later had similar age, gender, insurance, and disposition. Children treated with corticosteroids within 60 minutes had a 25-minute decrease in LOS compared with children treated for 61-minute or later (95% CI: 15–35), $p < .0001$. **Conclusions.** Administering corticosteroids to pediatric asthma patients in the ED within an hour of triage is associated with a 25-minute mean decrease in LOS. With large numbers of asthma visits, a 25-minute decrease in LOS for each child could have a significant impact on patient throughput in the ED.

Keywords acute asthma exacerbation, albuterol, dexamethasone, prednisolone

INTRODUCTION

Of the 22 million people in the United States diagnosed with asthma, 7 million are children (1). Asthma is a significant cause of morbidity in the pediatric population and accounts for more than 1 million visits to the Emergency Department (ED) each year (1). The current standard of care for children presented to the ED with a moderate-to-severe acute asthma exacerbation includes treatment with oral corticosteroids in conjunction with inhaled bronchodilators (2). The onset of action of inhaled short-acting bronchodilators such as albuterol is within minutes while oral corticosteroids reach their peak effect 4–6 hours after administration (3). Early administration of corticosteroids decreases hospital admission, but little is published evaluating length of stay (LOS) and timing of corticosteroid dosing in the ED (4).

With overcrowding and rising lengths of stay a problem for many EDs, early treatment with systemic corticosteroids may offer an avenue to decrease the LOS for patients with asthma. Our hypothesis was that early corticosteroid treatment within 60 minutes of triage would decrease the mean LOS in the ED by 10 or more minutes. The 60-minute mark was chosen based on a previous quality study suggesting patients with earlier administration of corticosteroids had a shorter LOS. The current study was carried out to obtain more subjects and data in order to

determine whether there is a true association. In addition, 60 minutes may be a reasonable amount of time to set as a clinical goal or marker for ongoing quality initiatives as it appears to be practically possible in a busy and urban ED.

METHODS

We conducted a retrospective chart review of children who presented to the Connecticut Children's Medical Center's (CCMC's) ED for the treatment of an acute asthma exacerbation. This study was approved by the CCMC Institutional Review Board. Charts were initially screened for inclusion and then audited for exclusion criteria by co-investigators. Children between the ages of 2 and 18 years who presented to the ED with an acute asthma exacerbation and received oral prednisone or dexamethasone in the ED during the 1-year period between 1 January 2007 and 31 December 2007 were included in the study. Children who did not receive oral corticosteroids in the ED, had significant medical co-morbidities, or were already on corticosteroids prior to arriving in the ED were excluded from the study. Only children who received oral corticosteroids were included in this study. Children who vomited and subsequently received a second dose intravenously or intramuscularly were excluded. Co-morbidities include cystic fibrosis, congenital heart disease, and bronchopulmonary dysplasia. For children who had returned to the CCMC ED with an asthma exacerbation within 7 days, only the initial visit was included in the study.

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An acute asthma exacerbation was defined as having signs of an exacerbation (wheezing and a Modified Pulmonary Index Score (MPIS) of 1 or greater if documented) and received at least one bronchodilator in the ED. The MPIS is a validated clinical asthma score used to assess the severity and outcome of an asthma exacerbation in hospitalized pediatric patients (5). The MPIS uses several indicators including oxygen saturation, accessory muscle use, inspiratory-to-expiratory flow ratio, degree of wheezing, heart rate, and respiratory rate to assign a score of 0–18, 18 being the most severe. For the purpose of this study, MPISs of 0–6 were considered mild asthma exacerbations, 7–10 moderate, and 11 or over severe exacerbations.

Treatment for children with asthma is guided by a standardized asthma treatment algorithm (see Figure 1). The same algorithm was in effect throughout the study period. The algorithm is based on severity of the asthma exacerbation (MPIS): mild, moderate, or severe. Children with mild asthma are given albuterol, and corticosteroids are suggested. The dose for both is based on the child's weight (see Table 1). Children with moderate or severe asthma exacerbations are treated with albuterol and atrovent together in addition to corticosteroids. The choice of corticosteroid (prednisolone or dexamethasone) is made by the physician caring for the patient. The dose for prednisone/prednisolone is 2 mg/kg with a maximum of 60 mg, and the dose for dexamethasone is 1 mg/kg with a maximum of 12–16 mg. Children with severity that persists in the moderate or severe category are treated with a long (1-hour) albuterol treatment, and then disposition is made by the physician. Additional medications are

TABLE 1.—Medication dosing.

MDI treatments (with spacer)		
≤10 Kg	4 puffs	Use facemask OR mouthpiece
>10 Kg	8 puffs	Use mouthpiece
Short albuterol treatments		
	Albuterol (mg)	Atrovent (500 µg)
≤10 Kg	2.5	1 vial
>10 Kg	5	1 vial
Long albuterol treatments		
	Albuterol (mg)	Total volume (with NS)
≤10 Kg	10	8 mL
>10 Kg	20	8 mL

determined by the treating physician. The order and timing of asthma medications are not specified. There is a standing order for the triage nurse to provide the first dose of albuterol and corticosteroid prior to physician evaluation, if a treatment room is not immediately available or no physicians are immediately available. Use of these orders is variable and not required.

The timing of corticosteroid administration was automatically calculated by the Electronic Medical Record (EMR). It was defined as the difference in minutes between the time of quick triage, done when the patient arrives in the ED, and the time of administration of the medication by the nurse. LOS was also automatically calculated by the EMR. The LOS was defined as the difference in minutes between the time of quick triage and the discharge time which is entered as the patient leaves the treatment room. A more detailed nursing

	β-AGONISTS	CORTICOSTEROIDS	MONITORS
MILD EXACERBATION PEFR > 80% or MPIS < 7 RAO ₂ sat ≥ 95%	MDI with spacer Q15 minutes x 3 ≤ 10 Kg: 4 puffs > 10 Kg: 8 puffs OR Albuterol nebulized Q 15 minutes x 3 Assess after each treatment, may not require all 3 If worsening or no improvement, move to moderate exacerbation pathway Consider discharge: PEF > 80% or MPIS < 7	Consider 2mg/kg prednisone or equivalent (max 60mg) give ASAP	Pulse oximeter
MODERATE EXACERBATION PEFR 50–80% or MPIS 7–10	Short albuterol treatment with atrovent then Long albuterol treatment Assess every 15 minutes OR For younger children or those unable to tolerate long treatment: albuterol Q 15 minutes x 3 (atrovent in 1 st treatment) If worsening or no improvement, move to severe exacerbation pathway AND ALERT ATTENDING MD If improving, but not ready for discharge: consider admission Consider discharge: PEF > 80% or MPIS < 7	2mg/kg prednisone or equivalent (max 60mg) give ASAP	Pulse oximeter
SEVERE EXACERBATION PEFR < 50% or MPIS > 10 ALERT ATTENDING MD	Short albuterol treatment with atrovent then Long albuterol treatment OR For younger children or those unable to tolerate long treatment: albuterol Q 15 minutes x 3 (atrovent in 1 st treatment) Consider ancillary medications If worsening clinical condition or no improvement: ALERT ATTENDING Consult ICU team if MPIS ≥ 13 Give continuous nebulized albuterol until admission or transfer Consider starting an intravenous line	2mg/kg prednisone or equivalent (max 60mg) give ASAP	Pulse oximeter (Continuous) Cardiac

FIGURE 1.—**Asthma treatment algorithm.** Treatment for children with asthma is guided by this standardized asthma treatment algorithm. The algorithm is based on severity of the asthma exacerbation (MPIS): mild, moderate, or severe. Children with mild asthma are given albuterol, and corticosteroids are suggested. Children with moderate or severe asthma exacerbations are treated with albuterol and atrovent in addition to corticosteroids. Children with severity that persists in the moderate or severe category are treated with a long (1 hour) albuterol treatment, and then disposition is made by the physician.

assessment typically occurs after the patient enters a treatment room. Another option would have been to use the disposition time which is entered into the EMR by the treating physician; however, this may be entered before other processes, such as reviewing discharge instructions, are completed. We chose not to use disposition time in determining LOS because it does not reflect LOS as accurately as discharge time.

Statistical Analysis

Subjects were categorized in one of two study groups based on the time of dosing of the corticosteroid. Children receiving corticosteroids within 60 minutes of triage were compared to children receiving corticosteroids 61 minutes or more after triage. Descriptive statistics were calculated for demographic, clinical, and treatment characteristics within each group and the two groups were compared using either Student's *t*-test or chi-square test, based on the level of measurement. Confidence limits at 5% error were computed for averages. Comparisons testing the study hypothesis were also conducted within disease severity. All alpha levels were two sided.

RESULTS

Records were selected for 948 children who met the inclusion criteria and were admitted to the pediatric ED at CCMC during the study period of 12 months (1 January 2007–31 December 2007). Of these children, 66 were excluded according to the exclusion criteria, resulting in 882 study participants. The mean LOS for all study participants was 169 minutes (95% CI: 164–174). Subjects in both the study groups were similar in age, gender, ethnicity, insurance coverage, and discharge rates from the ED (Table 2). The group receiving corticosteroids in the first hour exhibited higher asthma severity ($p < .003$, $\chi^2 = 11.7$).

Children treated with corticosteroids within 60 minutes had a mean LOS of 157 minutes (95% CI: 151–164), whereas children treated later than 60 minutes had a mean LOS of 182 minutes (95% CI: 175–190) (Figure 2). These results showed a mean of 25-minute decrease in LOS in the ED for children who received corticosteroids within 60 minutes of triage (95% CI: 15–35, $p < .0001$). Within severity groups, the greatest difference in LOS was found among children categorized as moderate by MPIS. These children had a mean 38-minute decrease in LOS if treated with corticosteroids within the first hour ($p < .0005$).

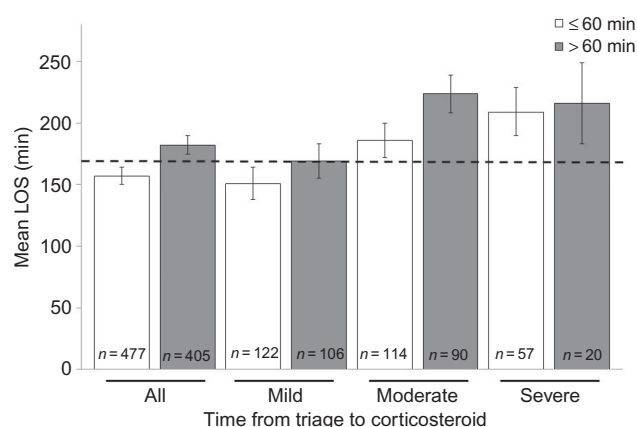


FIGURE 2.—**Corticosteroid dosing and asthma severity.** Study participants were separated according to the timing of corticosteroid treatment. Children treated within 60 minutes (white) had a mean LOS of 25 minutes less than children treated for 61 minutes or later (gray) ($p < .0001$). Study participants were further separated by MPIS severity. Children categorized with moderate asthma exacerbations had a 38-minute decrease in mean LOS if treated within 60 minutes ($p < .0005$). The dashed line represents the 169-minute mean LOS for all study participants. Differences in mean LOS in children categorized with mild or severe asthma exacerbations were not significant. Groups were compared using Student's *t*-test.

TABLE 2.—Patient characteristics.

	Corticosteroid ≤ 60 m (n = 477)	Corticosteroid > 60 m (n = 405)	P-value
Age (CI)	6.7 (6.3–7.1)	6.7 (6.3–7.1)	.73
Gender (female)	37.1%	39.0%	.66
African–American	30.2%	21.8%	
Caucasian	16.4%	21.8%	.02
Hispanic	45.9%	48.3%	
Other	7.34%	8.17%	
Self-pay	6.95%	6.42%	
Private insurance	34.3%	30.1%	.29
Public insurance	58.7%	63.5%	
Discharged	83.9%	84.7%	
Admitted	14.3%	14.8%	.18
Pediatric ICU	1.89%	0.49%	.
MPIS			
Mild (0–6)	41.6%	49.1%	.003
Moderate (7–10)	38.9%	41.7%	
Severe (≥11)	19.5%	9.26%	
Time to corticosteroids (min)			
Mean	36.1 (32.9–39.3)	109.2 (105.7–112.6)	
Median	35	93	

The study participants were treated with one of two oral corticosteroids, dexamethasone or prednisolone. During this study, the vast majority of children were treated with oral prednisolone. The mean dose of prednisolone was 44 mg with a range of 5–64 mg. The mean dose of dexamethasone was 10 mg with a range of 6–16 mg. Subjects treated with dexamethasone and prednisolone were similar in asthma severity (MPIS) (data not shown). We compared children treated with dexamethasone ($n = 101$) to those treated with prednisolone ($n = 781$) to determine whether the specific corticosteroid had any meaningful impact on LOS (Figure 3). The mean time from triage to corticosteroid treatment was 67 minutes (95% CI: 64–71) for children with prednisolone and 87 minutes (95% CI: 77–97) for children with dexamethasone. There was a 19-minute decrease in mean LOS for children who received dexamethasone compared with prednisolone (95% CI: 4–35), $p = .016$. Furthermore, treating with dexamethasone rather than prednisone within the first 60 minutes of triage decreased the mean LOS in our study population by 34 minutes (95% CI: 7–60), $p = .013$. These results suggest that treating early with dexamethasone may have a greater impact on LOS than prednisolone.

The impact of albuterol timing on LOS was also evaluated (Figure 4). We excluded 90 patients who did not receive albuterol. The two original study groups, those receiving corticosteroids within and after 60 minutes, were subdivided by the timing of the first albuterol treatment, either within or after 60 minutes of triage. Within the group of children who received corticosteroids within 60 minutes, we found no significant difference when albuterol was administered within 60 minutes or after 60 minutes ($p = .66$). Similarly, within the group of children that received corticosteroids after 60 minutes, we again found no significant difference when compared with children

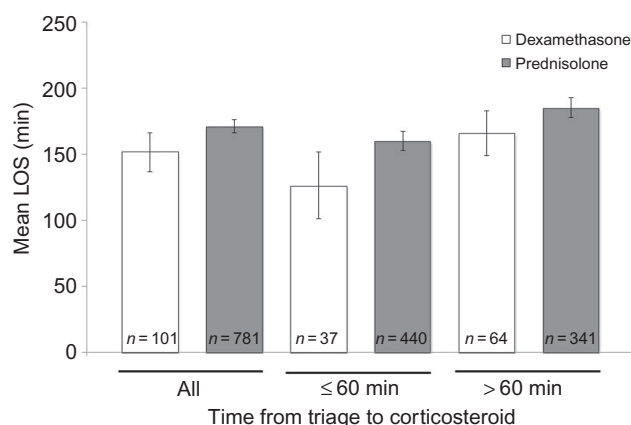


FIGURE 3.—**Dexamethasone compared to prednisolone.** Study participants were separated according to which corticosteroid, dexamethasone (white) or prednisone (gray), they received. Children who received dexamethasone had a 19 minute decrease in LOS ($p = .016$). Participants were further separated by the timing of treatment, either within 60 minutes or 61 minutes or later. Children treated within 60 minutes had a 34-minute decrease in LOS if treated with dexamethasone ($p = .013$). Children treated after 60 minutes had a 19-minute decrease in LOS if treated with dexamethasone ($p = .047$). Groups were compared using Student's *t*-test.

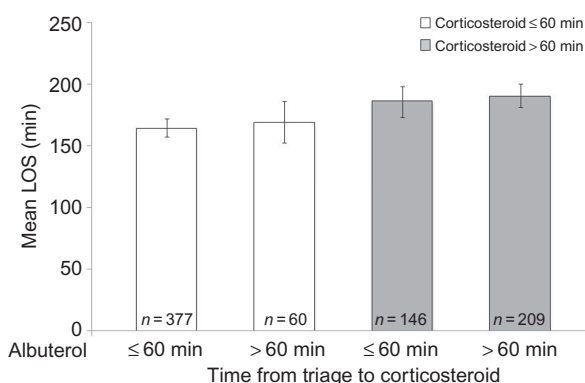


FIGURE 4.—**Effects of corticosteroids and albuterol on LOS.** Study participants were separated by timing of corticosteroid treatment, within (white) or after (gray) 60 minutes of triage, and then further separated by the timing of albuterol treatment, either within or after 60 minutes of triage. Of children treated with corticosteroids within 60 minutes there was no significant difference in LOS when albuterol was given within or after 60 minutes ($p = .66$). Of children treated with corticosteroids 61 minutes or later, there was also no significant difference in LOS when albuterol was given within or after 60 minutes ($p = .56$). Groups were compared using Student's *t*-test.

who received albuterol within or after 60 minutes ($p = .56$). These results suggest that early albuterol administration does not impact LOS beyond the timing of corticosteroid administration.

DISCUSSION

This study was conducted to evaluate the effect of the timing of corticosteroid administration on LOS for children who presented to the ED with an acute asthma exacerbation. This study shows that early corticosteroid treatment was associated with a meaningful reduction in the overall LOS. Because oral corticosteroids typically reach their maximum effect 4–6 hours after administration, early administration may not be considered a priority for many providers (3). This study suggests that corticosteroids have clinical benefits much sooner than anticipated. In this study, 46% of children received corticosteroids for 61 minutes or more after triage, suggesting that there is a large population in which there is potential to reduce overall LOS. ED overcrowding and rising lengths of stay are continuous obstacles in emergency care. Decreasing LOS by 25 minutes for this common condition could significantly impact the flow of all patients in the ED. With the high prevalence of asthma patients in many pediatric EDs, decreasing the LOS for this patient population could have significant positive impacts on ED efficiency and quality of care for many patients.

Other studies have reported early corticosteroid treatment to be effective in decreasing admittance rates. Rowe et al. assessed 12 randomized controlled studies involving 863 adults and pediatric patients for an association between hospital admission and timing of corticosteroids (4). This study showed that patients given corticosteroids within an hour of arrival were

significantly less likely to be admitted than other patients. Our study did not show a difference in admission rates (Table 2); however, disposition decisions were made within 3 hours for most children. A more recent study by Zemek et al. had similar findings in that triage nurse initiated corticosteroid administration to pediatric asthma patients decreased hospital admission rates. In addition, they reported a 44-minute decrease in ED LOS, further corroborating the results of this study (6).

Children included in the study were given either dexamethasone or prednisolone. We found dexamethasone-treated patients had a mean LOS 19 minutes less than children treated with prednisolone. When we separated the study population further according to the time of treatment, we found that in the subset of children receiving steroids within 60 minutes, those treated with dexamethasone had a mean LOS of 34 minutes less than those treated with prednisolone. These results suggest that, in addition to early corticosteroid treatment, the choice of dexamethasone over prednisolone may decrease LOS for pediatric asthma patients even more. Prednisolone is highly absorbed when taken orally and reaches peak plasma level in about 1 hour. Although its plasma half-life is 2–3 hours, its biologic half-life is 18–36 hours (7). Dexamethasone is five times more potent than prednisolone and has a faster onset of action and longer duration (8). This may account for the additional decrease in LOS for children receiving dexamethasone for asthma. Another study showed a similar decrease in ED LOS between dexamethasone (3.5 hour LOS) and prednisone (4.3 hour LOS), but the difference was not statistically significant. The admission rate was 9% for dexamethasone and 13.4% for prednisone, again not significant likely due to the small number of subjects (9). In this study, however, the prednisone dose was half of the dose used in our study, 1 mg/kg with a maximum dose of 30 mg. One study compared dexamethasone to prednisone in pediatric patients (10). LOS was not evaluated; however, this study found slight differences in vomiting between children who received these medications but no significant differences in clinical efficacy. Other studies have reported the improved or similar longer-term outcomes for children treated with dexamethasone or prednisolone (9–12).

It is interesting that early administration of albuterol within 60 minutes did not have a sizable impact on LOS for children with asthma. Onset of action for albuterol is fast, within 5–8 minutes, and reaches peak concentrations within 10–15 minutes. Maximum mid-expiratory flow rate typically peaks 30 minutes after dosing (11). Within the two original study groups (separated by timing of corticosteroid administration), we found no significant difference when albuterol was given within 60 minutes or after 60 minutes, suggesting early albuterol administration does not impact LOS beyond the timing of corticosteroid administration. This implies that asthma treatment algorithms and quality improvement projects should focus on early administration of corticosteroids and not just albuterol.

Limitations

This is a retrospective study, and other factors influencing LOS were not assessed. For example, administration of additional asthma medications that are not included in the treatment algorithm and are left to the discretion of the treating physician may also affect LOS. Furthermore, although albuterol timing was shown not to affect LOS beyond corticosteroid timing, the effects of the total dose of albuterol on LOS were not assessed. Overall, business of the ED, including the number of treating physicians, the total number of patients, and the number of critically ill patients, likely affect LOS and data to assess “business” were not available to include in the analyses. Finally, different providers may affect LOS in various ways including preference for one corticosteroid and a tendency to send children home sooner. Because decisions regarding steroids could have been made by the nurse at triage, the senior resident, a mid-level provider, or 1 of 12 attending physicians, it was not possible to assess the contribution of the provider to LOS.

There were other limiting factors as well. MPIS was not available for all subjects, limiting analysis of asthma severity. In addition, the primary objective of this study was not to make comparisons between prednisolone and dexamethasone and a considerably smaller group of subjects received dexamethasone compared to prednisolone. If more children had received dexamethasone, it is possible that the differences in LOS between the two corticosteroid groups may have been more pronounced.

CONCLUSIONS

The results of this study showed that early administration of oral corticosteroids, within 60 minutes of arrival, to children with acute asthma in the ED was associated with significantly decreased LOS. Treatment protocols or algorithms in the ED including early administration of corticosteroids may improve LOS for children with asthma and might improve the flow of all patients in an ED that cares for a large number of children with asthma. In addition, dexamethasone appeared to reduce LOS more than prednisolone. We plan to study these findings further with a prospective randomized controlled trial.

DECLARATION OF INTEREST

The authors report no conflicts of interest.

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